

## REMARKS

Claim 1 is amended to recite the metal-oxygen compound is solid as supported at page 9, line 22-28 disclosing it is preferably a powder, and can be pre-treated to form conglomerates. Thus, in Claim 1 all the reactants are gases, e.g., CO, or solids, e.g., solid carbon and solid metal-oxygen compound. It is noted solid carbon typically contains Boudouard Carbon and iron-carbide

Claim 1 is amended to recite the first reaction stage is performed at a temperature of at most 650°C as supported at page 8, line 26.

Claim 1 is amended to recite the second reaction stage is performed at a temperature of at most 900°C as supported by the upper end of the range disclosed at page 8, line 34. .

Claim 1 is amended to recite discharging the solid carbon and solid metal oxygen compound from the first stage as supported at page 8, lines 10-11 and page 12 lines 30-32 and page 16, lines 30-32.

Claim 1 is amended to recite the reduced metal-oxygen compound is solid as supported at page 8, lines 21-24 and page 15, line 18. Thus, the end product is a solid product

Claim 1 is also amended to include the features of Claims 2 and 4.

Amended Claim 2 recites the solid carbon comprises carbon formed by dissociation of carbon monoxide by the Boudouard reaction as supported at page 5.

### I. Restriction Requirement

Applicant confirms the previous election, without traverse, of the method claims 1-21 and 27 of Group I.

### II. 35 U.S.C. §102

Claims 1-3, 5-10, 13-17, and 19-21 have been rejected under 35 USC §102(b) as being anticipated by Stephens, Jr. (US 4,053,301, hereinafter Stephens).

Stephens has been cited for teaching a method of reducing a metal-oxygen compound comprising a two stage method of transforming iron oxide to steel.

Thus, the Office action says Stephens discloses in the first reaction stage, CO gas is passed into a reaction chamber containing iron-oxygen compound (col. 2, lines 9-26) under

conditions so that CO is converted to solid carbon and CO<sub>2</sub>. This introduces the formed solid carbon to the iron-oxygen compound (col. 2 lines 1-4, where an excess of carbon is available to supply sufficient heat upon combustion). Also, the Office action says Stephens discloses a second reaction stage, the carbon, introduced to the iron-oxygen compound in the first reaction stage, reduces the iron-oxygen compound to iron-carbide. The Office action refers to col. 1, line 62 in asserting the iron-carbide under the conditions taught by Stephens would inherently promote both the reduction of iron oxide to iron carbide and the Boudouard reaction of CO to carbon and CO<sub>2</sub>.

This rejection is respectfully traversed.

Stephens teaches iron ore concentrate is fed to a fluidized bed reactor and is made to react with a gas comprising hydrogen, CO, CO<sub>2</sub> and methane. In a first step the oxides are converted to iron-carbide. In a second step this iron carbide is subsequently fed to a basic oxygen furnace (BOF). In such a furnace the iron-carbide is melted and the excess carbon is burnt with added oxygen to meet the energy needs of the BOF process. The steel resulting from such a process is molten steel.

This is very different from the presently claimed process where all reactants remain solid throughout (except the gases of course). The temperatures in step 2 are much higher than in the present method. The high temperature leads the carbon from the iron-carbon to react with the oxygen and form CO and leave the iron as a metal behind.

Amended Claim 1 recites a maximum temperature for step 2 (900°C taken from claim 17) and this distinguishes over Stephens. In the process described by Stephens all carbon is in the form of Fe<sub>3</sub>C (see column 2, line 20-26). It is not intended to produce solid carbon as Boudouard carbon in Stephens, wherein it is an important step in the present invention.

The reactions occurring in the second stage of Stephens are not the reaction recited for the second stage of present Claim 1. In Stephens second stage the materials are molten and the iron-carbide is reduced to iron by burning off the carbon from the carbide by added oxygen, whereas in the second stage recited by present Claim 1 the metalliferous compound is reduced by the Boudouard Carbon (BC) made in the first stage.

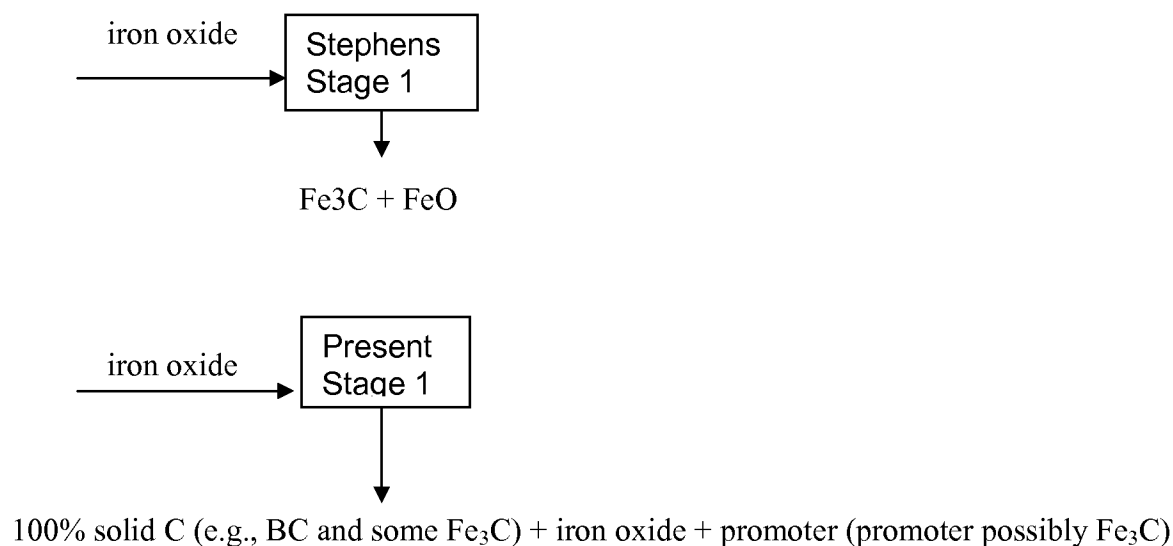
The Stephens fluidized bed unit is fed iron ore (iron oxide), H<sub>2</sub>, CO, CO<sub>2</sub> and CH<sub>4</sub> and converts the iron oxide to Fe<sub>3</sub>C and discharging Fe<sub>3</sub>C from one discharge opening and discharges

the gases H<sub>2</sub>, CO, CO<sub>2</sub>, CH<sub>4</sub> and H<sub>2</sub>O from another opening. As stated at col. 3, lines 44-47, the oxides are reduced to iron and the iron converted to the carbide in a continuous process in the fluid bed reactor in which the reducing carburizing gases are added together. The iron carbide is a mixture of carbides having the molecular formulas Fe<sub>2</sub>C and Fe<sub>3</sub>C with the Fe<sub>3</sub>C content being predominant (col. 3, lines 1-4). In the second stage the Fe<sub>3</sub>C is contacted with O<sub>2</sub> and converted to steel (col. 1, lines 64-66).

In contrast, present Claim 1 describes a first stage which is fed iron oxide, reacts the CO to form CO<sub>2</sub> and solid carbon by the Boudouard reaction. In this first stage some of the oxides will inevitably have reacted to form Fe<sub>3</sub>C, and due to the temperature hematite will have transformed into magnetite. However, the main aim of the first stage is to convert CO into solid carbon.

Also, present Claim 1 describes a second stage in which the metal oxide (e.g., iron oxide) is reduced to iron, while the solid carbon acts as a reducing agent, except for the part that has already reacted in stage 1 to form Fe<sub>3</sub>C (as mentioned above).

The following diagrams (simplified to omit gases) summarize some difference between the first stages.



Moreover, in regard to claim 20, the Office action notes the Boudouard reaction and the iron oxide to iron carbide reaction occurs in the fluidized bed unit, indicating the solid iron

carbide reaction product produced in the second reaction stage is made available to the first reaction stage. It is presently submitted the solid product from the present first stage contains iron oxide and that of Stephens does not.

It is submitted the dependent claims distinguish over Stephens at least as does their base claim.

### III. 35 U.S.C. §103

#### A. Claim 4 is rejected under 35 U.S.C. §103 as being unpatentable over Stephens.

In regard to claim 4, the Office action indicates the process of Stephens does not teach the second reaction stage performed at a higher temperature than the first stage. The Office action indicates Stephens teaches the second stage is at an elevated temperature of about 1,100°F to 1,300°F and discovery of the workable range by routine experimentation of the temperature range taught by Stephen would not be inventive.

This rejection is respectfully traversed. Stephens second stage is molten, thus at a temperature of molten steel whereas present Claim 1 recites the second stage temperature is at most 900°C.

#### B. Claims 11, 12, 18 and 27 are rejected under 35 U.S.C. 103 as being unpatentable over Stephens in view of the article Reduction and Sintering of Fluxed Iron Ore Pellets-A comprehensive Review (hereinafter the “article”)

It is submitted the article does not make up for the above-described deficiencies of Stephens.

Moreover, the conglomerate in claim 11, 12 and 27 are for example pellets or sinter comparable to that which are used in the blast furnace. So Applicant does not see the link with the article. Possibly the Office action misunderstood the term conglomerate.

From internet article: Iron oxides can come to the blast furnace plant in the form of raw ore, pellets or sinter. The raw ore is removed from the earth and sized into pieces that range from 0.5 to 1.5 inches. This ore is either Hematite ( $\text{Fe}_2\text{O}_3$ ) or Magnetite ( $\text{Fe}_3\text{O}_4$ ) and the iron content ranges from 50% to 70%. This iron rich ore can be charged directly into a blast furnace without any further processing. Iron ore that contains a lower iron content must be processed or

beneficiated to increase its iron content. Pellets are produced from this lower iron content ore. This ore is crushed and ground into a powder so the waste material called gangue can be removed. The remaining iron-rich powder is rolled into balls and fired in a furnace to produce strong, marble-sized pellets that contain 60% to 65% iron. Sinter is produced from fine raw ore, small coke, sand-sized limestone and numerous other steel plant waste materials that contain some iron. These fine materials are proportioned to obtain a desired product chemistry then mixed together. This raw material mix is then placed on a sintering strand, which is similar to a steel conveyor belt, where it is ignited by gas fired furnace and fused by the heat from the coke fines into larger size pieces that are from 0.5 to 2.0 inches. The iron ore, pellets and sinter then become the liquid iron produced in the blast furnace with any of their remaining impurities going to the liquid slag.

Regarding claim 18, the article is said to teach nickel-oxide is a useful catalyst for a direct reduction of iron oxide to iron carbide.

Applicant respectfully submits nickel is expensive and it influences the properties of the steel, so if you do not have to use it, you do not.

#### IV. Conclusion

In view of the above, it is respectfully submitted all objections and rejections are overcome. Thus, a Notice of Allowance is respectfully requested.

Respectfully submitted,

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